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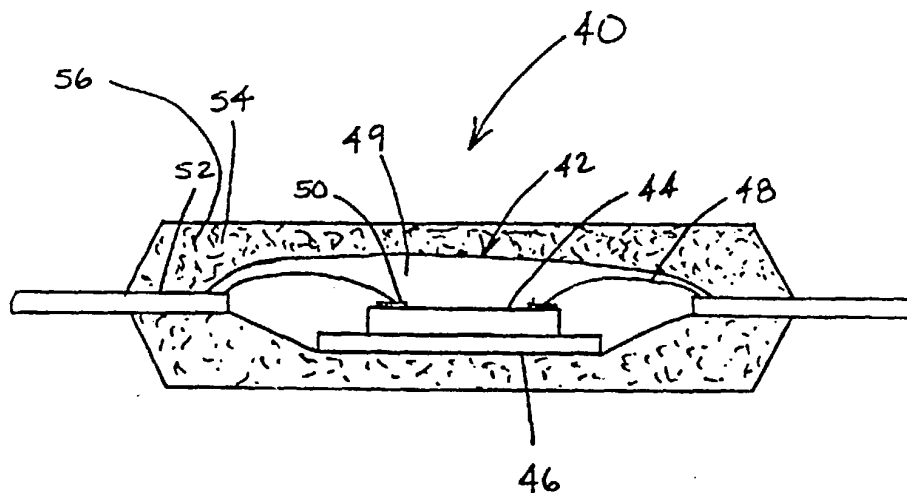
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(54) Title: AN INTEGRATED CIRCUIT PACKAGE ENCAPSULATED BY FIBER LADEN MOLDING MATERIAL AND ITS METHOD OF MANUFACTURING



(57) Abstract

An integrated circuit package (40) encapsulated by a fiber (56) or other such particle laden molding material (54) is disclosed herein. The package (40) includes a support member (46) which supports an IC chip (44). An array of bonding wires (48) electrically interconnects respective input/output terminals on the IC chip to conductive leads (52) defined by the support member (46). The IC chip (44), bonding wires (48) and portions of the support member (46) are encapsulated by an overall fiber laden molding material (54). In a method of the invention, an intermediate assembly which includes the IC chip (44), support member (46) and bonding wires (48) is encapsulated by supporting the assembly in a mold cavity and injecting a fiber (56) or other such particle laden molding material (54) into the cavity and around the assembly. A mold including a unique movable gate is also disclosed herein.

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**AN INTEGRATED CIRCUIT PACKAGE ENCAPSULATED BY FIBER
LADEN MOLDING MATERIAL AND ITS METHOD OF
MANUFACTURING**

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By Inventor

Peter M. Weiler

Background of the Invention

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The present invention relates generally to an integrated circuit package and more particularly to an integrated circuit package which is encapsulated in a high strength and/or high thermal conductivity molding material which includes fibers or other such strength enhancing particulate material.

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A typical integrated circuit package is comprised of (1) an IC chip including an array of chip input/output terminals, (2) means for supporting the chip, for example, either a leadframe or substrate, including an array of electrically conductive leads, (3) bonding wires electrically connecting the chip input/output terminals with respective ones of the electrically conductive leads, and (4) plastic material encapsulating the IC chip, support means and bonding wires. This overall package is typically manufactured by first supporting the IC chip on the support member. The bonding wires are then attached to electrically interconnect the input/output terminals of the IC chip to the electrically conductive leads of the support member. This subassembly is then placed in a cooperating mold to encapsulate the IC chip, support

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means and bonding wires in plastic.

Attention is now directed to Figure 1, which diagrammatically illustrates an intermediate step in the production of a prior art IC package of the type described immediately above. An intermediate IC assembly, which is generally indicated by the reference numeral 10, is shown prepared for overall encapsulation. Intermediate IC assembly 10 includes an IC chip 12 including an array of chip input/output terminals 13. Chip 12 is supported on a suitable support member 14 which can be, for example, a leadframe or a dielectric substrate. The support member includes an array of electrically conductive leads 16 electrically connected to respective chip input/output terminals by an array of bonding wires 18.

Still referring to Figure 1, a mold for use in encapsulating intermediate IC assembly 10 is generally indicated by the reference numeral 20. Mold 20 includes a runner 22 which leads from an external supply of molding material (not shown) to a mold cavity 24 for accommodating a flow of molding material 26 into mold cavity 24. A fixed gate 28 is located in runner 22 at the point where the runner enters mold cavity 26. The fixed gate 28 is in actuality formed as a narrowed passage within the runner 22 which serves to ease the separation of runner 22 from the finished molded package and has the undesirable result of restricting the flow of molding material into the mold cavity 24 through the runner 22. Intermediate IC assembly 10 is supported within mold cavity 24 for overall encapsulation by the molding material. Molding material 26, in order to be useful for this application, must be quite viscous and of a consistency which will not

clog fixed gate 28 as it passes through the latter and onward into the mold cavity. As the molding material is injected into the cavity it flows around the intermediate IC assembly including bonding wires 18, IC chip 12 and at least a portion 29 of electrically conductive leads 16
5 which are within the mold cavity.

Following the injection of the molding material into the mold cavity, the mold material is allowed to harden. After hardening, the mold material forms a monolithic structure which includes a package
10 portion 30 surrounding the IC assembly and a runner portion 32 formed within the runner. Upon removal of the IC package from the mold, which is not shown, runner portion 32 must be broken away from package portion 30.

15 While the method of producing a prior art integrated circuit package, as depicted in Figure 1, does produce an IC package which is generally satisfactory for its intended purpose, certain disadvantages due to the method of manufacture exist which limit the final capabilities of the IC package thereby produced with regard to its strength and
20 thermal conductivity. These disadvantages are directly related to fixed gate 28 in mold 20 and the plastic molding compound used to form package portion 30, and will be described immediately hereinafter.

A first disadvantage, which may increase production costs, lies in
25 the fact that the fixed gate, as discussed above, leaves runner portion 32 of the molding material attached to package portion 30 of the molding material which encapsulates the actual IC. The runner portion must be broken away from the package portion upon removal of the IC

package from the mold. If the molding material is made significantly stronger, the runner portion will be more difficult to remove and the package could be damaged, in some cases, by the breaking away of the runner portion.

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A second and even more significant disadvantage of the fixed gate mold is related to the limited types of molding materials which are amenable to use with it. When considering thermal and strength properties of a representative IC package, the composition of the molding material encapsulating the package is of primary consideration. In the prior art method presented above, the molding material must be quite viscous and possess a smooth consistency to allow it to pass through fixed gate 28 in runner 22 without clogging the gate. This restricts the available molding materials suitable for use to a rather narrow range which excludes most types of fillers including fibers of any type.

As will be seen hereinafter, the present invention removes the limitations in molding materials required by a fixed gate mold thereby to allow the use of a much broader range of molding materials and provide IC packages which possess previously unattainable characteristics with regard to strength and thermal properties.

Summary of the Invention

As will be described in more detail hereinafter, there is disclosed herein an integrated circuit package, its method of manufacture, and a
5 unique mold used by the method wherein the aforescribed restrictions in molding materials used to encapsulate the package are eliminated. These packages, like the package illustrated in Figure 1, include an IC chip having an array of chip input/output terminals, a support member having an array of electrically conductive leads and
10 supporting the IC chip, and an array of bonding wires electrically connecting the chip input/output terminals with respective ones of the electrically conductive leads. However, in accordance with the present invention, the overall integrated circuit package including the IC chip, the bonding wires and portions of the electrically conductive leads are
15 encapsulated by a molding material laden with a fiber or other suitable type of particulate.

In the manufacture of an integrated circuit package, a method of encapsulating an intermediate assembly is disclosed. The intermediate
20 assembly includes a support member having an array of electrically conductive leads, an IC chip having an array of chip input/output terminals, and an array of bonding wires. The IC chip is supported on the support member and the bonding wires electrically interconnect the conductive leads with respective ones of the chip input/output
25 terminals. The intermediate assembly is encapsulated by providing a mold assembly which defines a mold cavity, supporting the intermediate assembly including the IC chip and the bonding wires in the mold cavity, injecting a fiber or other such particle laden molding

material into the mold cavity and around the intermediate assembly and allowing the molding material to harden.

A mold for use in manufacturing an integrated circuit package, in accordance with the method described above which utilizes a fiber or other such particle laden molding material, is also disclosed herein. The mold defines a mold cavity and a material transfer passage which leads into the cavity, the material transfer passage being suitably configured to allow a flow of the fiber or other such particle laden molding material through the material transfer passage. In accordance with the present invention, the mold further includes means for selectively blocking the flow of the molding material to prevent the flow of the latter into or out of the mold cavity through the material transfer passage once the cavity has been filled with and prior to the hardening of the molding material.

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Brief Description of the Drawings

The present invention may be understood by reference to the following detailed description taken in conjunction with the drawings, in
5 which:

FIGURE 1 is a cross-sectional diagrammatic elevational view which illustrates an intermediate step in the manufacture of a prior art integrated circuit assembly.
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FIGURE 2 is a cross-sectional diagrammatic elevational view which illustrates an IC package manufactured in accordance with the present invention.

15 FIGURE 3 is a cross-sectional diagrammatic elevational view of a mold including a movable gate which is used in a method of the present invention.

FIGURE 4 is a cross-sectional diagrammatic elevational view of the
20 mold illustrated in Figure 4 including an intermediate IC assembly in place in the mold cavity, shown to illustrate an intermediate step in the method of the present invention for manufacturing an IC assembly.

FIGURE 5 is a cross-sectional diagrammatic elevational view
25 similar to Figure 4, which illustrates the completion of the encapsulation of the IC package of the present invention.

Detailed Description of the Invention

Having described Figure 1 previously, attention is immediately directed to Figure 2, which illustrates an integrated circuit package manufactured in accordance with a method of the present invention and generally designated by reference numeral 40. Package 40 includes an intermediate assembly 42 which itself includes an IC chip 44, a support member 46, an array of bonding wires 48 and a hardened plastic blob 49. IC chip 44 includes an array of chip input/output terminals 50 each one of which is connected to a respective one of a plurality of electrically conductive leads 52, which are integral with support member 46, by a respective one of bonding wires 48. Support member 46 may be a leadframe or a substrate, either of which are typical of the support members used in the prior art. Blob 49 covers the bonding wires in a protective manner consistent with and described in U.S. Patent Application Serial No. 08/225,900, filed April 11, 1994 and entitled Plastic Encapsulating Integrated Circuit Package Having Protective Barrier For Its Bonding Wires, and Method, which application is assigned to the assignee of the present invention and is incorporated herein by reference. The function of the blob will be described in detail herein in conjunction with a description of a method of manufacturing the IC package of the present invention, which follows hereinafter.

Continuing to refer to Figure 1 and in accordance with the present invention, intermediate assembly 42 is encapsulated by a molding material 54. Molding material 54 may incorporate a wide variety of new components not previously seen in IC packages, for example, such as fillers. These IC packages will provide advantages over prior art IC

packages based upon the characteristics of the components present in molding material 54. In the present example, molding material 54 is laden with a plurality of fibers 56 which may include, for example, glass fibers or aluminum nitride fibers. The addition of these fibers provides
5 specific advantages in comparison to prior art IC packages, some of which will now be discussed.

A first advantage realized as a direct result of the incorporation of fibers into the molding material is an IC package possessing a strength
10 not seen heretofore. While the imparting of strength to materials which contain fibers such as these is well known in the art, they have not been seen in materials used in the overall encapsulation of an IC package due to the problems encountered in the method of encapsulation of the package, which problems are solved by the present invention.

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A second advantage resulting from inclusion of fibers in the molding material lies in the thermal conductivity of the package. Significant heat is produced by IC chips of certain types such as, for example, power amplifiers. It is therefore a continuing goal of IC
20 package designers to provide packages capable of conducting ever increasing levels of thermal energy away from the IC chip through the package materials themselves. The aforementioned glass and aluminum nitride fibers typically possess a higher thermal conductivity than the molding material or resin to which they would be added. Consequently,
25 the thermal conductivity of the molding material, which is laden with the fibers, will increase. The result is a package having a higher thermal conductivity which is capable of removing an increased amount of thermal energy from the IC chip or, for that matter, any device

within the package which produces heat.

While the present invention contemplates the utilization of a fiber laden plastic encapsulant, the present invention is not limited thereto. Any suitable and compatible strength enhancing and/or thermally
5 conductive particulate is contemplated by the present invention including, for example, aluminum nitride, graphite, or fiberglass.

Reference is now made to Figure 3 which illustrates a mold for use
10 in encapsulating an IC package manufactured in accordance with the present invention and generally designated by reference numeral 60. Mold 60 includes an upper mold half 62 and a lower mold half 64. Lower mold half 64 includes a material transfer passage 66 which leads from an external source of molding material (not shown) to a cavity 68
15 defined within the mold itself. In one possible configuration, a movable gate 70 is positioned in a gate channel 72 at a point 74 where the material transfer passage adjoins the mold cavity. Gate 70 is designed to move vertically from an open position, allowing the flow of molding material through the full width of material transfer passage 66 to a
20 closed position (shown in phantom) which completely blocks passage 66 to prevent any further flow of molding material either into or out of cavity 68. Gate 70 includes a surface 72 which defines a portion of the package outline when the gate is in its closed position, as shown. This unique gate, unlike the prior art fixed gate shown and described above,
25 opens to the full width of the material transfer passage, permitting molding materials which would clog the prior art fixed gate to flow through the passage, past the movable gate and into the mold cavity. Movable gate 70 allows the use of molding materials which are new in

the encapsulation of IC packages such as, for instance, those containing fibers.

Many configurations of a mold including a movable gate may be provided which are useful in the method of the present invention. For example, the gate may be positioned at a different location in the material transfer passage, the gate may move horizontally to block the passage or may include a shape which is altered from the preferred embodiment which is shown and described herein. All of these configurations and variations are considered to be within the scope of the present invention. The use of this mold in a method of the present invention will be described immediately hereinafter.

Turning now to Figure 4 and in accordance with a method of the present invention, an intermediate assembly 80 is placed within mold cavity 68 of mold 60, which was previously described in the discussion relating to Figure 3. Intermediate assembly 80 includes an IC chip 82 having an array of chip input/output terminals 83. Chip 82 is supported on a suitable support member 84 which can be, for example, a leadframe or a dielectric substrate. The support member includes an array of electrically conductive leads 86 electrically connected to respective chip input/output terminals by an array of bonding wires 88. A hardened plastic blob 90 protects the bonding wires, in accordance with previously referenced U.S. Application 08/225,900, against the inflow of a fiber laden molding material 92 when it is injected into the mold cavity. Without the protection offered by the plastic blob, the bonding wires would be washed by the inflow of molding material possibly becoming disconnected or shorting to one another. Wire wash

has been a significant concern in the manufacture of prior art IC packages and, in this instance, it is vital to protect the bonding wires against wire wash since a fiber laden molding material will place much greater wash stresses on the bonding wires. Other means of protecting the bonding wires against wire wash may be developed such as, for example, a hollow plastic enclosure which surrounds the intermediate assembly. These means are considered to be within the scope of the invention as claimed.

Continuing to refer to Figure 4 and with movable gate 70 in its opened position, fiber laden molding material 92 is injected into mold cavity 68 through passage 66. Since movable gate 70 is in its opened position, the entire width of the passage is presented to the flow of molding material whereby to avoid clogging of the passage by the fibers carried in the material. The molding material, in its viscous state, fills passage 66 to surround intermediate assembly 80.

Referring to Figure 5, movable gate 70 is moved to its closed position prior to the hardening of molding material 90, as illustrated. The closing of the gate separates a first portion 90a of molding material which remains in the material transfer passage from a second portion 90b which encapsulates the intermediate assembly. In this particular configuration of movable gate 70, surface 72 of the gate actually defines a portion of the package outline of the encapsulating molding material. After the gate is closed the molding material is allowed to harden and the IC package is removed from the mold (not shown). It is mentioned here that first portion 92a of the molding material within the material transfer passage is separated from second portion 92b of the package

itself by closed gate 70 such that the first portion does not need to be broken away from the IC package, thereby avoiding the risk of damage to the package. This is particularly advantageous considering the increased strength of the fiber laden molding material.

5

It should be understood that the IC package and mold of the present invention may be embodied in many other specific forms and produced by other methods without departing from the spirit or scope of the present invention. Therefore, the present examples are to be
10 considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein, but may be modified within the scope of the appended claims.

What is claimed is:

1. In the manufacture of an integrated circuit package, a
5 method of encapsulating an intermediate assembly which includes a
support member having an array of electrically conductive leads, an IC
chip having an array of chip input/output terminals and an array of
bonding wires, said IC chip being supported on the support member and
said bonding wires electrically interconnecting the conductive leads
10 with respective ones of the chip input/output terminals, said method
comprising the steps of:

- a) providing a mold assembly which defines a mold
cavity;
15
- b) supporting said intermediate assembly including the
IC chip and the bonding wires in said mold cavity;
- c) injecting into the mold cavity and around the
20 intermediate assembly a particulate laden molding material; and
- d) allowing said molding material to harden.

2. A method according to Claim 1 including the step of
25 providing a protective barrier over said bonding wires sufficient to
prevent said bonding wires from moving against the force of the
particulate laden molding material as the latter is injected into said
mold cavity and caused to flow over the intermediate assembly.

3. A method according to Claim 1 wherein the step of providing a mold assembly includes the step of providing a material transfer passage leading into said mold cavity and wherein the step of
5 injecting the molding material into the mold cavity includes the step of injecting the molding material through the material transfer passage.

4. A method according to Claim 3 including the step of closing the material transfer passage after injecting the molding material into
10 the mold cavity and prior to its hardening.

5. A method according to Claim 4 wherein the step of closing said material transfer passage includes the steps of providing a gate within said passage movable between a first position for opening the
15 passage and a second position for closing the passage, and moving said gate between its first position to open the passage and allow the flow of molding material through said material transfer passage and into said mold cavity and a second position to block the material transfer passage after the mold cavity has been filled with said molding material.

20

6. A method according to Claim 5 wherein said mold cavity defines a package outline and said movable gate in its closed position defines a portion of said outline.

25 7. A method according to Claim 1 wherein said particulate laden molding material includes fibers.

8. A method according to Claim 7 wherein said fibers have a

high thermal coefficient.

9. A method according to Claim 8 wherein the fibers are glass fibers.

5

10. A method according to Claim 8 wherein the fibers are aluminum nitride.

11. A method according to Claim 2 wherein the step of
10 providing said protective barrier includes forming a hardened plastic blob over said bonding wires.

12. In the manufacture of an integrated circuit package, a method of encapsulating an intermediate assembly which includes a
15 support member having an array of electrically conductive leads, an IC chip having an array of chip input/output terminals and an array of bonding wires, said IC chip being supported on the support member and said bonding wires electrically interconnecting the conductive leads with respective ones of the chip input/output terminals, said method
20 comprising the steps of:

a) providing a mold assembly which defines a mold cavity, a material transfer passage leading into said mold cavity and a gate movable between a first position for opening said passage and a
25 second position for closing said passage and defining part of said cavity;

b) supporting said intermediate assembly including the IC chip and the bonding wires in said mold cavity;

c) while maintaining said gate in its first, passage-opened position, injecting a molding material through the material transfer passage and into the mold cavity around the intermediate assembly;

5

d) thereafter, but before the molding material within said cavity hardens, moving said gate to its second passage-closed position; and

10

e) allowing said molding material to harden after closing said gate.

13. A method according to the method of Claim 12 wherein a protective barrier consisting of a hardened plastic blob is provided over said bonding wires sufficient to prevent said bonding wires from moving against the force of the molding material as it flows over the intermediate assembly and the injected molding material is particle laden.

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14. A method according to the method of Claim 13 wherein the particles are fibers.

15. An integrated circuit package comprising:

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a) an IC chip including an array of chip input/output terminals;

b) a support member including an array of electrically conductive leads which are provided for connection with the input/output terminals of said IC chip, said support member supporting said IC chip including its array of chip input/output terminals;

5

c) an array of bonding wires electrically connecting said chip input/output terminals with respective ones of said electrically conductive leads; and

10

d) a particle laden molding material encapsulating the overall package including said IC chip, said bonding wires, and portions of said support member including portions of said electrically conductive leads.

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16. An integrated circuit package in accordance with Claim 15 including a protective barrier disposed over said bonding wires between the latter and said molding material, said protective barrier being designed so that, during formation of the package, it prevents said bonding wires from moving against the force of said molding material as the latter is caused to flow in place over the IC chip, support member and bonding wires.

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17. An integrated circuit package in accordance with Claim 15 wherein said particle laden molding material includes fibers.

25

18. An integrated circuit package in accordance with Claim 17 wherein said fibers include a high thermal coefficient.

19. An integrated circuit package in accordance with Claim 18 wherein the fibers are glass fibers.

20. An integrated circuit package in accordance with Claim 18
5 wherein the fiber members are aluminum nitride.

21. An integrated circuit assembly in accordance with Claim 16 wherein said protective barrier includes a hardened plastic blob formed over said bonding wires.

10

22. A mold for use in manufacturing an integrated circuit package encapsulated in a molding material which itself includes a plurality of fiber or other such particulate members, said mold defining a mold cavity and a material transfer passage which leads into said
15 cavity, said material transfer passage being suitably configured to allow a flow of said molding material therethrough, said mold further including means for selectively blocking the flow of the molding material to prevent the flow of the latter into or out of the mold cavity through the material transfer passage once the cavity has been filled
20 with and prior to the hardening of the molding material.

23. A mold in accordance with Claim 22 wherein the mold includes an upper mold half and a lower mold half.

24. A mold in accordance with Claim 23 wherein said material transfer passage is defined within one of said mold halves.

25. A mold in accordance with Claim 22 wherein said blocking

means includes a gate selectively movable between an open position which allows the flow of molding material through the material transfer passage into the mold cavity and a closed position which blocks the material transfer passage to prevent further flow of the molding
5 material into or out of the mold cavity through the material transfer passage.

26. A mold in accordance with Claim 25 wherein said mold cavity defines a package outline and said movable gate in its closed
10 position defines a portion of said outline.

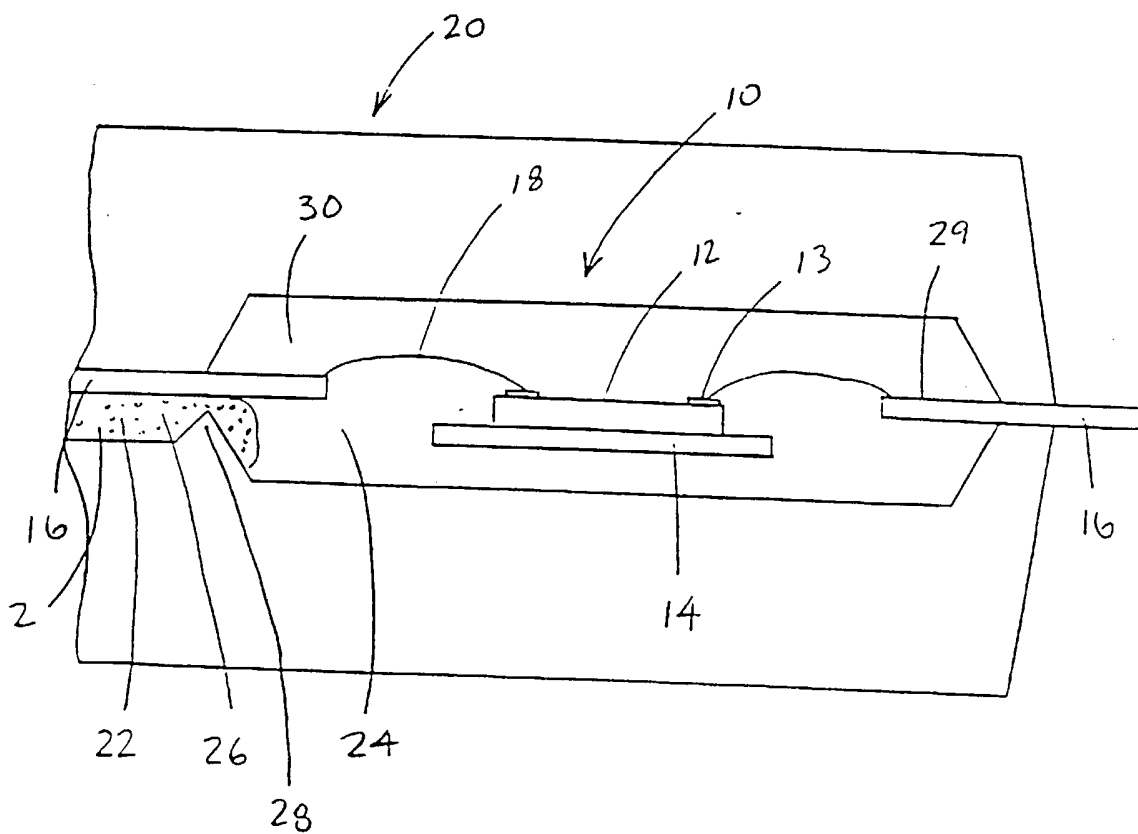


FIGURE 1

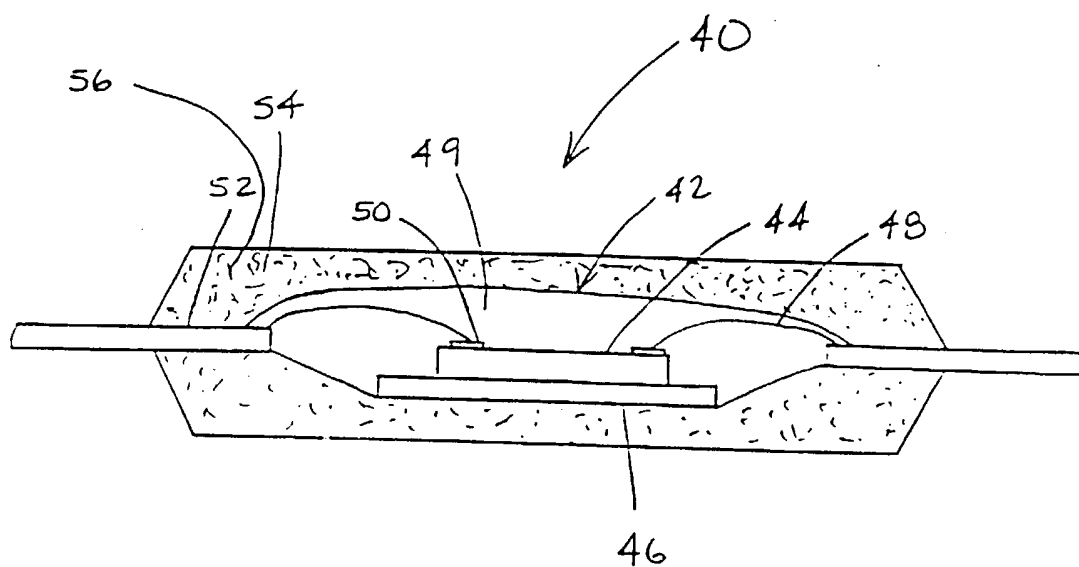


FIGURE 2

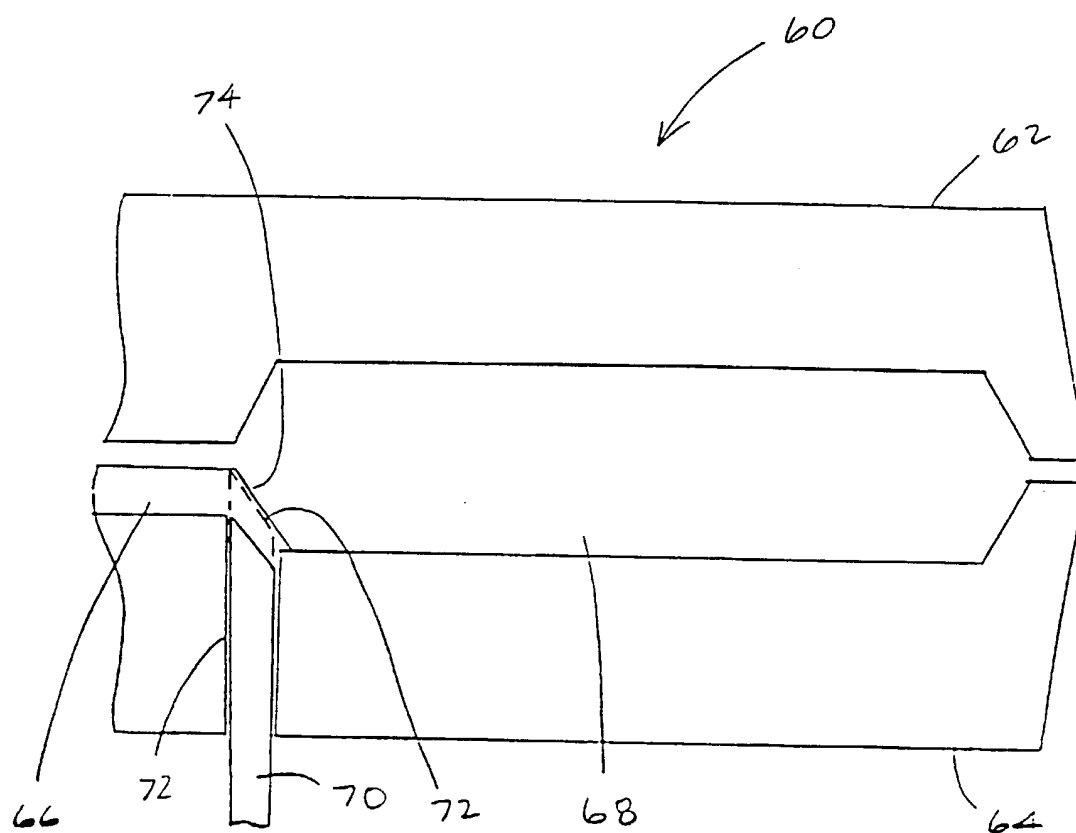


FIGURE 3

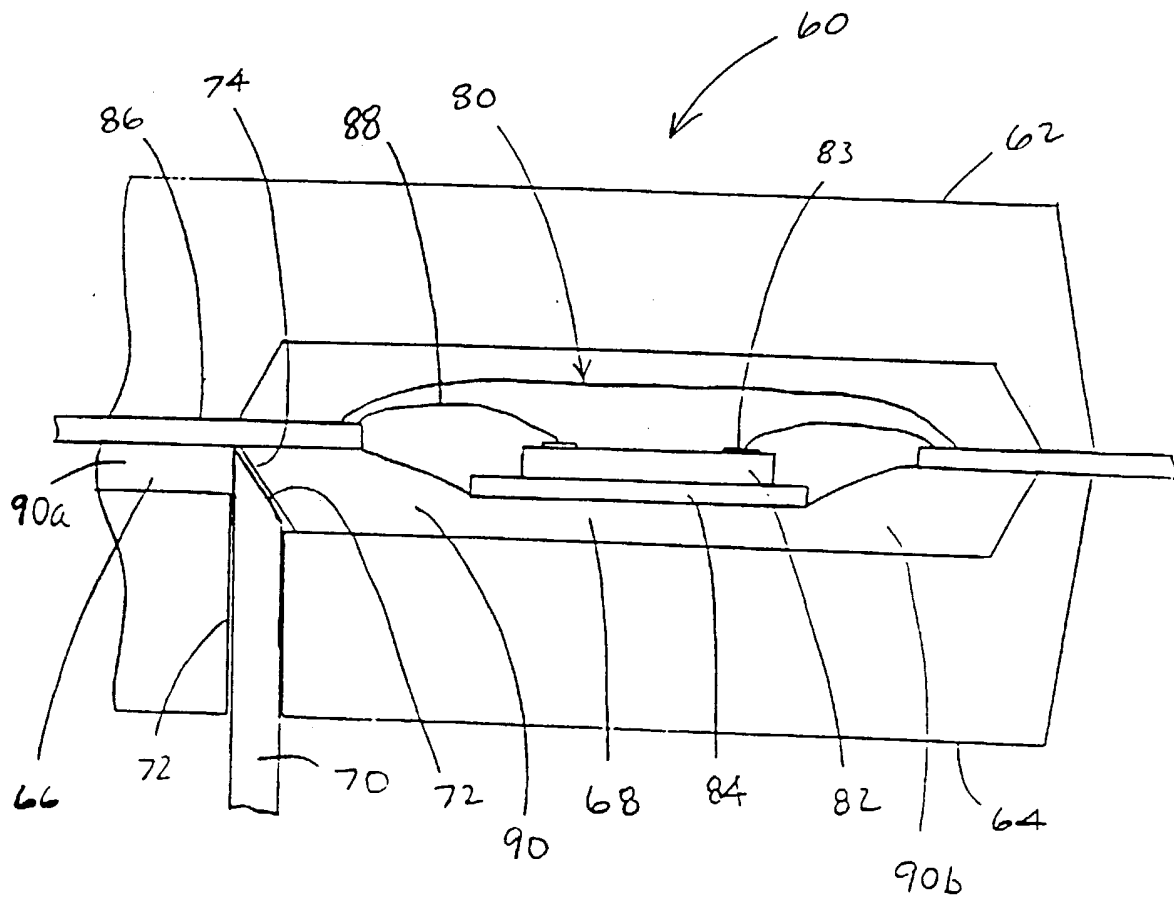


FIGURE 5

INTERNATIONAL SEARCH REPORT

Int'l Application No
PCT/US 95/16059

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01L23/31 H01L21/56

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 012, no. 348 (E-659), 19 September 1988 & JP,A,63 104455 (OKI ELECTRIC IND CO LTD), 9 May 1988, see abstract	1,3,7-9, 15,17-19
Y	---	10,20
X	FR,A,1 572 077 (ITT INDUSTRIES INC) 20 June 1969	1,2,11, 16,21
Y	see the whole document	3-6,13, 14
A	---	
	US,A,5 331 205 (PRIMEAUX WILLIAM F) 19 July 1994 see the whole document	1,2, 11-13, 16,21

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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

3 April 1996

Date of mailing of the international search report

17. 04. 96

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 95/16059

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 010, no. 175 (E-413), 20 June 1986 & JP,A,61 024241 (NIPPON DENKI KK), 1 February 1986,	12,22-26
Y	see the whole document	3-6,13, 14

X	PATENT ABSTRACTS OF JAPAN vol. 008, no. 044 (E-229), 25 February 1984 & JP,A,58 201333 (NIPPON DENKI KK), 24 November 1983, see the whole document	12,22-26

X	PATENT ABSTRACTS OF JAPAN vol. 017, no. 694 (M-1531), 17 December 1993 & JP,A,05 237864 (NEC CORP), 17 September 1993, see the whole document	12,22-26

Y	PATENT ABSTRACTS OF JAPAN vol. 010, no. 192 (E-417), 5 July 1986 & JP,A,61 035542 (NEC CORP), 20 February 1986, see abstract	10,20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 95/16059

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR-A-1572077	20-06-69	CH-A- 483724 DE-A- 1764554 GB-A- 1206759 NL-A- 6810225	31-12-69 26-08-71 30-09-70 22-01-69
US-A-5331205	19-07-94	NONE	